REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
May 1, 1995

3. REPORT TYPE AND DATES COVERED
Final 3/15/94 - 3/14/95

4. TITLE AND SUBTITLE
High Speed Variability in X-ray Binary Systems

5. FUNDING NUMBERS

6. AUTHOR(S)
J.N. Imamura

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
University of Oregon
Eugene, OR 97403

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Research Laboratory
Washington, DC 20735

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Freely available upon request

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Portions of this work were performed in collaboration with Drs. M. Wolff and K. Wood of the Naval Research Laboratory. We are engaged in a long-term project to develop numerical models for the high-speed variability seen in the energy output of the x-ray binary systems, in general, and for the white dwarf x-ray binary systems known as the AM Herculis objects (from hereon the AM Her objects), in particular, and to develop modern tools for the analysis of time series data.

14. SUBJECT TERMS
Hydrodynamics; Time Series Analysies; X-rays

15. NUMBER OF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

N00014-94-G012

High-Speed Variability in X-ray Binary Systems

James N. Imamura
Institute of Theoretical Science and Department of Physics,
University of Oregon, Eugene, OR 97403

April 24, 1995

1 Overview

Portions of this work were performed in collaboration with Drs. M. Wolff and K. Wood of the Naval Research Laboratory. We are engaged in a long-term project to develop numerical models for the high-speed variability seen in the energy output of the x-ray binary systems, in general, and for the white dwarf x-ray binary systems known as the AM Herculis objects (from hereon the AM Her objects), in particular, and to develop modern tools for the analysis of time series data.

2. Accomplishments

The AM Her objects are x-ray binary systems composed of strongly magnetic ($B_* = 10$ - 60 MG) white dwarfs and low-mass companion stars. They are characterized by strongly polarized optical emission and x-ray emission modulated on the orbital/rotational periods of the systems. In addition to the coherent rotational/orbital variations, the AM Her objects also exhibit aperiodic and quasi-periodic variability on time scales ranging from seconds to years. The quasi-periodic variability divides into two classes: 1 - 3 *sec* quasi-periodic oscillations (QPOs) detected in the optical; and tens of seconds to several minutes QPOs seen in the optical and x-rays. Neither class of QPOs is well-understood.

J. Imamura continued development of a radiation-hydrodynamics numerical code designed to model the shocks found in the AM Her systems. The initial phase of this work involved integrating the radiation moment equations into the hydrodynamic code. We are currently implementing a simplified equation set into an existing hydrodynamics computer code. We are studying shocks with an isotropic and grey radiation process. Such work, in addition to its value as a developmental technique, is applicable to accretion onto nonmagnetic high mass white dwarfs and nonmagnetic neutron stars. After this step is completedm we will tackle the highly anisotropic and strongly frequency dependent radiation process of cyclotron emission.

J. Imamura, in collaboration with groups from NASA/Ames Research Center and the Naval Research Laboratory, pursued the dripping handrail nonlinear dynamics model as a possible alternative model for the AM Her QPOs. Imamura et al. showed that this simple model produces QPO activity similar to that seen in the AM Her systems and also to that seen in the neutron star low mass x-ray binaries.

J. Imamura completed an investigation of the properties of radiating shock waves where there is significant separation between electron and ion temperatures and considered the effects of realistic white dwarf cooling functions on the properties of nonradial shock oscillation modes. Imamura showed that two temperature effects tend to de-stabilize radiative shock waves to oscillatory instabilities of the postshock relaxation region and that surprisingly, Compton cooling destabilized nonradial oscillation modes – Compton cooling strongly stabilizes radial oscillations.

Publications

Refereed Publications

"Quasi-Periodic Oscillations and Blob Accretion in the AM Herculis Objects," Steiman-Cameron, T. Y., Scargle, J. D., Young, K., Wolff, M. T., Wood, K. S., Crutchfield, J. P., Imamura, J. N., and Williams, W. T. 1994, *The Astrophysical Journal*, 435, 775.

"Stability Properties of Two-Temperature White Dwarf Radiative Shock Waves," Imamura, J. N., Aboasha, A., Wolff, M. T., and Wood, K. S., 1995 *The Astrophysical Journal*, submitted.

Nonrefereed Publications

"Dynamics of Accretion in AM Herculis Systems: Models for High Mass White Dwarfs," Wolff, M. T., Wood, K. S., and Imamura, J. N., 1994, in Proc. of University of Maryland meeting on X-ray Binaries, in press.